4 Analysis of Characterization of Ecological Effects

Habitat and Distribution of Study Fish Species

Brief descriptions of the life histories of the 30 fish species selected for the Navigation Study Fish Ecological Risk Assessment are presented in this section. The fish species include piscivores (fish that eat other fish), planktivores (fish that eat plankton), and omnivores (fish that eat both plants and animals or anything that they can consume). Maps of the current distribution of each fish species were developed using information from Rasmussen (1979), Pitlo (1987), Fremling et al. (1989), Holland-Bartels et al. (1990b), Lerczak et al. (1994), Pitlo et al. (1995), Gutreuter (1992, 1997), Koel et al. (1997), Gutreuter, Dettmers, and Wahl 1998; Gutreuter et al. (1997a, 1977b, 1997c, 1997d, 1998), and Burkhardt et al. (1997, 1998). The maps were reviewed and verified by fisheries biologists familiar with the river systems.[1] Upper Mississippi River Conservation Committee (UMRCC) commercial fisheries statistics were also used to assist in the development of the current distributions of the 30 fish species.

Adequate fish population data are not available for the UMR-IWW System; therefore, the distribution of each of the 30 fish species is described qualitatively. The presence of a species within a particular pool can be rare, occasional, common, or abundant. “Rare” means that the species does not usually appear (or rarely appears) in sample collections, the populations are small, and the species may or may not be on the verge of extirpation (Pitlo et al. 1995). “Occasional” means that the species is occasionally collected, the species is not generally distributed, and local concentrations of the species may occur (Pitlo et al. 1995). “Common” means that the species is commonly collected in most sample collections and that the species can make up a large portion of some samples (Pitlo et al. 1995). “Abundant” means that large numbers are always collected during surveys (Pitlo et al. 1995).

[1] Steve Gutreuter, U.S. Geological Survey, Upper Mississippi Science Center, and Scott Whitney, U.S. Army Engineer District, Rock Island, formerly with the Illinois Natural History Survey.

The general within-pool distribution (main channel, main channel border, or backwaters) of the larval stages, juvenile stages, and adult stages of the 30 fish species selected for this ecological risk assessment was developed using the pertinent references cited in this report and the UMR-IWW System Aquatic Habitat Classification System developed by Wilcox (1993) (Figures 2, 3, and 4). As these figures show, a life stage of a particular fish species can be present in more than one habitat type. This information was used to estimate the w_i value for the CEM model.

Sturgeons

Sturgeons (Family Acipenseridae) and the distantly related paddlefish are generally regarded as the most primitive surviving bony fishes (Etnier and Starnes 1993). They occur only in the northern hemisphere and are the largest freshwater fishes; life spans of the larger species may exceed 150 years (Etnier and Starnes 1993). Sturgeon flesh is now well accepted as food, but these fishes are better known as a principal source of caviar (Etnier and Starnes 1993). Sturgeon were of considerable commercial value during the early 1900s, but overfishing, pollution, and the construction of dams have greatly reduced populations (Pflieger 1997).

Three species of sturgeon (lake sturgeon, pallid sturgeon, and shovelnose sturgeon) are indigenous to parts of the Mississippi River. The lake sturgeon is rare in the entire UMR and in the Alton, La Grange, and Peoria Pools of the IWW (Figure 5). It is listed as endangered in Iowa, Illinois, and Missouri and is a species of special concern in Minnesota (Table 2). As part of the Long Term Resource Monitoring Program (LTRMP), a few lake sturgeon have been collected in regular fish surveys from 1991 through 1997 in UMR Pools 4, 8, 13, and 26 (Burkhardt et al. 1997, 1998; Gutreuter et al. 1997a, 1997b, 1997c, 1997d, 1998). In 1984, the Missouri Department of Conservation initiated a stocking program to reestablish populations of lake sturgeon in Missouri (Pflieger 1997). The pallid sturgeon is absent from most of the UMR-IWW System; it occurs rarely in UMR Pools 26 and 27 and in the open river (Figure 6). Regular fish surveys of UMR Pools 4, 8, 13, 26; the open Mississippi River; and the IWW La Grange Pool since 1991 have resulted in the collection of only three pallid sturgeon/shovelnose sturgeon hybrids from the open river in 1997 (Burkhardt et al. 1997, 1998; Gutreuter et al. 1997a, 1997b, 1997c, 1997d, 1998). The pallid sturgeon is listed as endangered on the Federal Threatened and Endangered Species List as well as for Missouri (Table 2). Only the shovelnose sturgeon is common in the UMR (Figure 7); it is found occasionally in the IWW. The life histories of all three sturgeon species are very similar.

The lake sturgeon is an inhabitant of lakes and rivers, where it occurs primarily over firm, silt-free bottoms of sand, gravel, and rock (Pflieger 1997). The lake sturgeon feeds primarily on benthic organisms; in searching for food, it swims close to the bottom with the ends of its sensitive barbels dragging (Etnier and Starnes 1993; Pflieger 1997). Adults typically migrate up rivers to spawn, and spawning occurs from April through June (Etnier and Starnes 1993). Adults do not spawn every year, and the interval between spawning is 4-9 years for

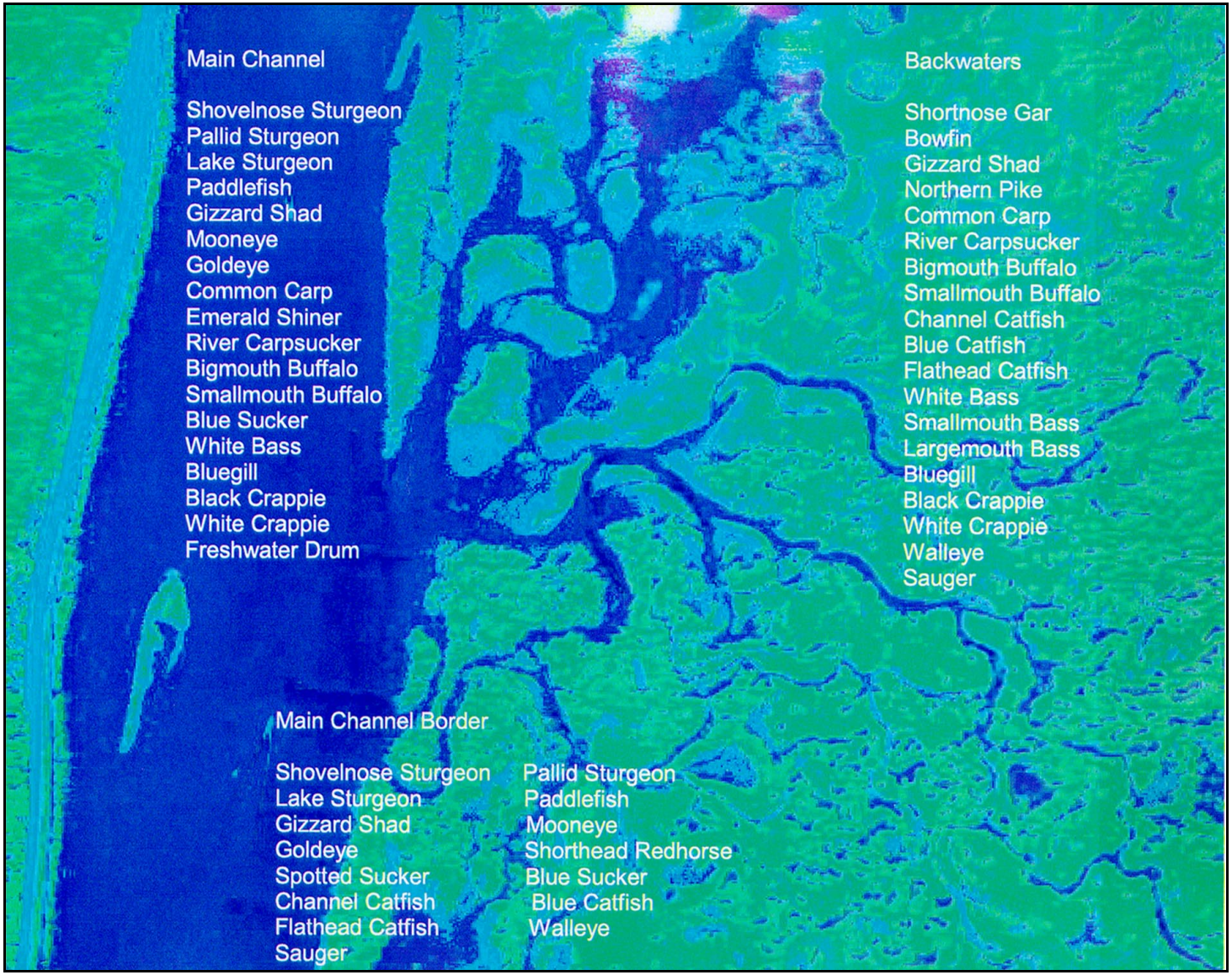

Figure 2. The general within-pool distribution of the larval stages of the study fish species

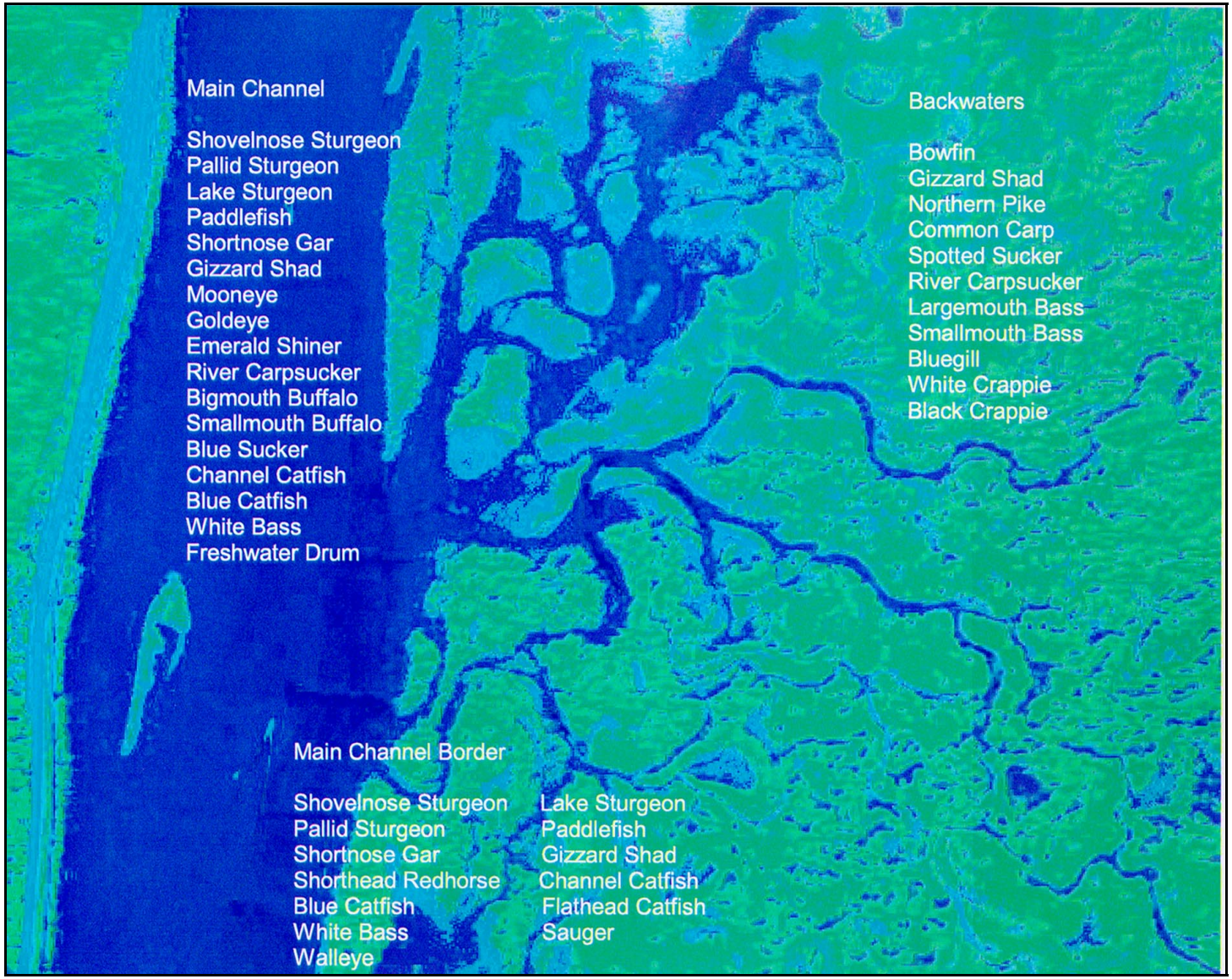

Figure 3. The general within-pool distribution of the juvenile stages of the study fish species

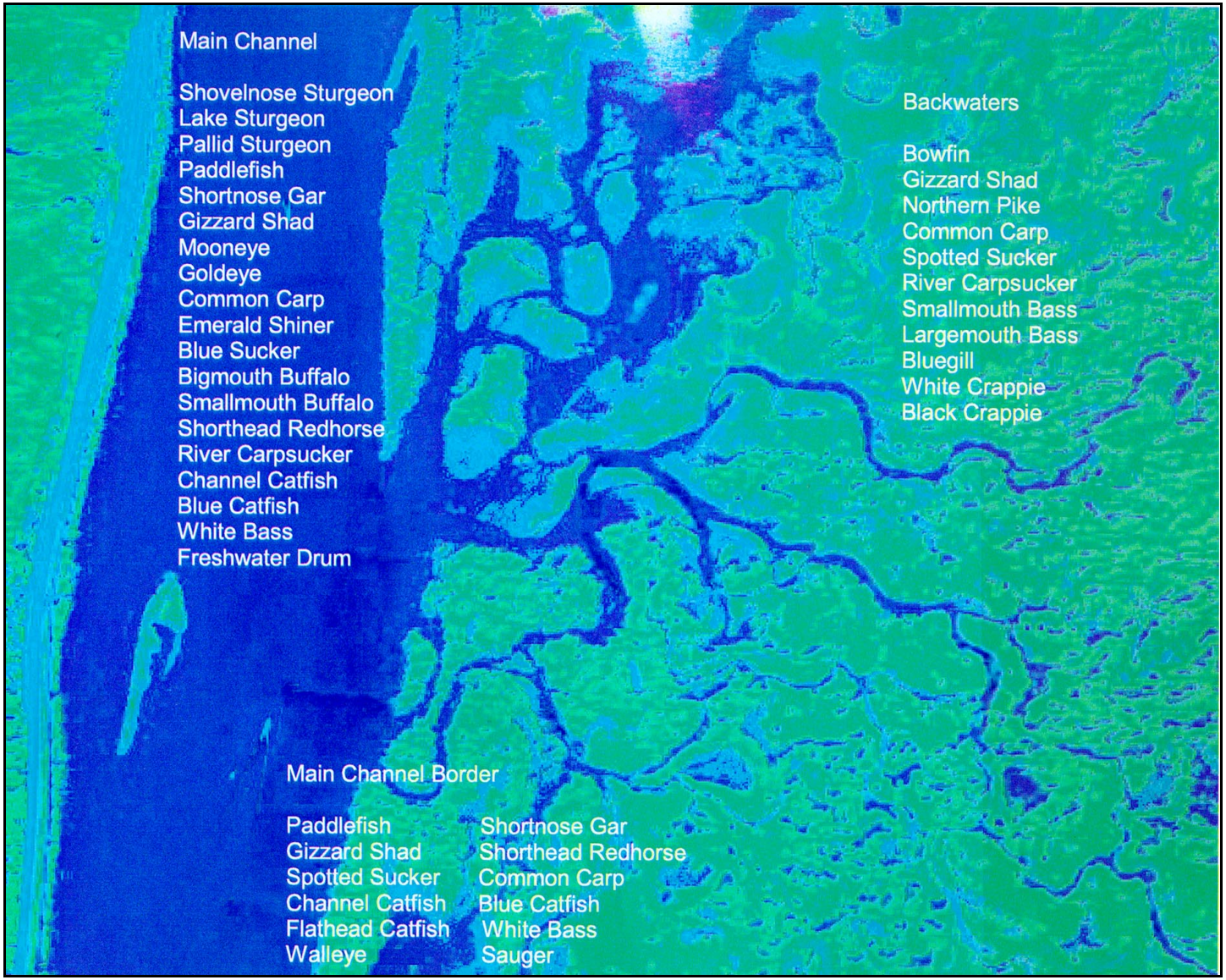

Figure 4. The general within-pool distribution of the adult stages of the study fish species

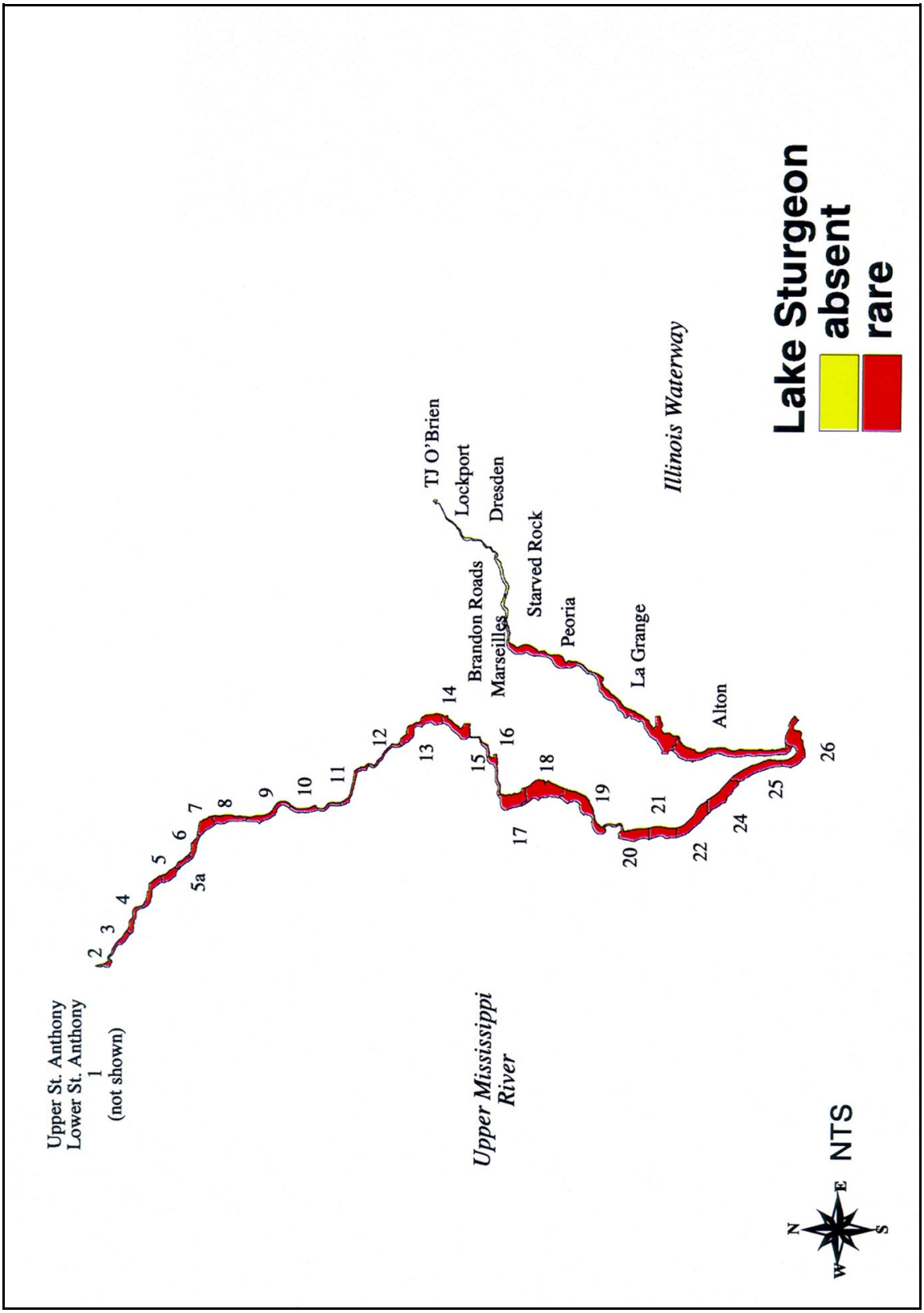

Figure 5. Distribution and abundance of lake sturgeon in the Upper Mississippi River and the Illinois Waterway

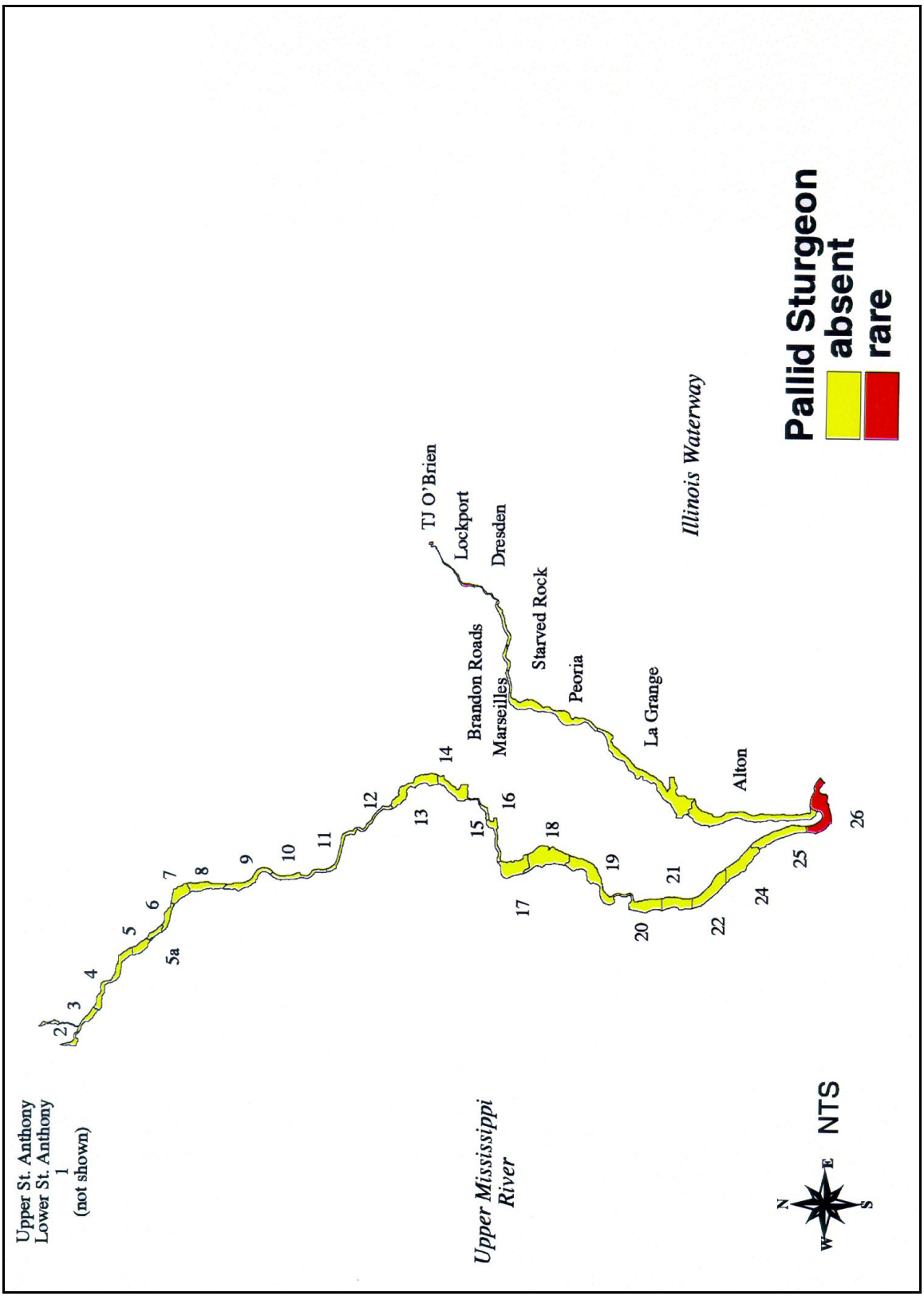

Figure 6. Distribution and abundance of pallid sturgeon in the Upper Mississippi River and the Illinois Waterway

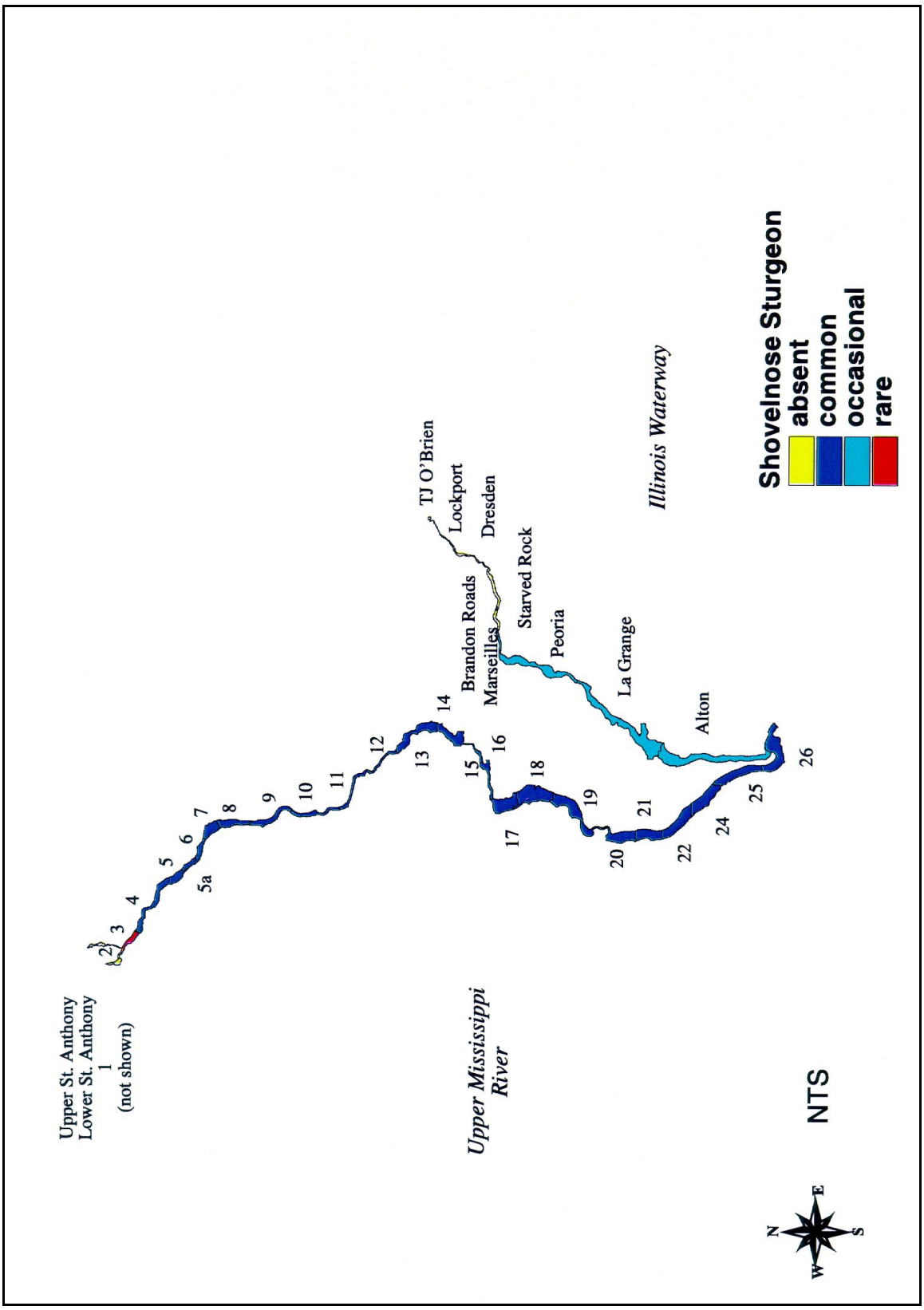

Figure 7. Distribution and abundance of shovelnose sturgeon in the Upper Mississippi River and the Illinois Waterway

females and yearly or in alternate years for males (Etnier and Starnes 1993). The large, adhesive eggs are deposited on the shallow, gravelly riffles of streams or the rocky shoals of lakes (Pflieger 1997). Lake sturgeon grow and mature slowly, with first spawning occurring at about 14-25 years of age (Etnier and Starnes 1993; Pflieger 1997). Males and females have similar growth rates, but females have longer life spans and reach much larger sizes (Etnier and Starnes 1993). Lake sturgeon live to be much older than other North American freshwater fish, with maximum age estimates of as much as 154 years (Etnier and Starnes 1993).

Very little is known concerning the rare pallid sturgeon (Etnier and Starnes 1993). The pallid sturgeon is an inhabitant of the open channels of large, turbid rivers; it lives on the bottom in areas having strong current and firm substrate, along sandbars, and behind wing dikes with deeply scoured trenches (Pflieger 1997). Although the pallid sturgeon often occurs in association with the shovelnose sturgeon, it is more restricted to areas of strong current (Pflieger 1997). The diet of pallid sturgeon consists of immature aquatic insects and small fish (Etnier and Starnes 1993). When and where pallid sturgeon spawn are not known; however, because it hybridizes with shovelnose sturgeon, spawning conditions for the two species must be similar (Etnier and Starnes 1993; Pflieger 1997). Females may spawn for the first time at ages 15 to 20 and at intervals of several years thereafter (Pflieger 1997). The pallid sturgeon is considerably larger than the shovelnose sturgeon (Etnier and Starnes 1993), and studies have shown that it attains an age of at least 41 years (Pflieger 1997).

The shovelnose sturgeon inhabits deep channels of rivers near the bottom (Figure 4), often in areas of swift current with a sand or gravel bottom (Becker 1983; Etnier and Starnes 1993; Pflieger 1997). It is the sixth most abundant species captured near wingdams, closing dams, and other structures that accelerate water flow or direct flow toward the main channel (Pitlo 1981; Becker 1983). Shovelnose sturgeon are omnivores but commonly eat immature stages of aquatic insects (Littlejohn et al. 1985). Young of the year have been collected in the main channel and main channel border areas near wingdams (Farabee 1979) (Figure 3). Larvae have rarely been collected in drift studies on the UMR but are suspected to occur in the main channel drift based on the reproductive strategy of the species (Holland et al. 1984; Holland-Bartels et al. 1990b; Gutreuter, Dettmers, and Wahl 1998). Spawning of shovelnose sturgeon has been reported in late April through early June (Smith 1979, Holland-Bartels et al. 1990b). Spawning is believed to occur in open channels of large rivers in areas of strong current over rocky or gravel bottoms (Pflieger 1997). Upstream migrations into smaller streams for spawning have been reported, and spawning may also occur in the tailwaters of navigation dams (Holland-Bartels et al. 1990b).

Paddlefishes

The primitive freshwater family Polyodontidae contains only two living species: *Polyodon spathula* in the Mississippi-Ohio-Missouri River systems and *Psephurus gladius* in the Yangtze River of China (Pflieger 1997). Paddlefish are commonly found in most of the UMR-IWW System (Figure 8). Paddlefish have been collected in LTRMP fish surveys from 1991 through 1997 in UMR Pools 4

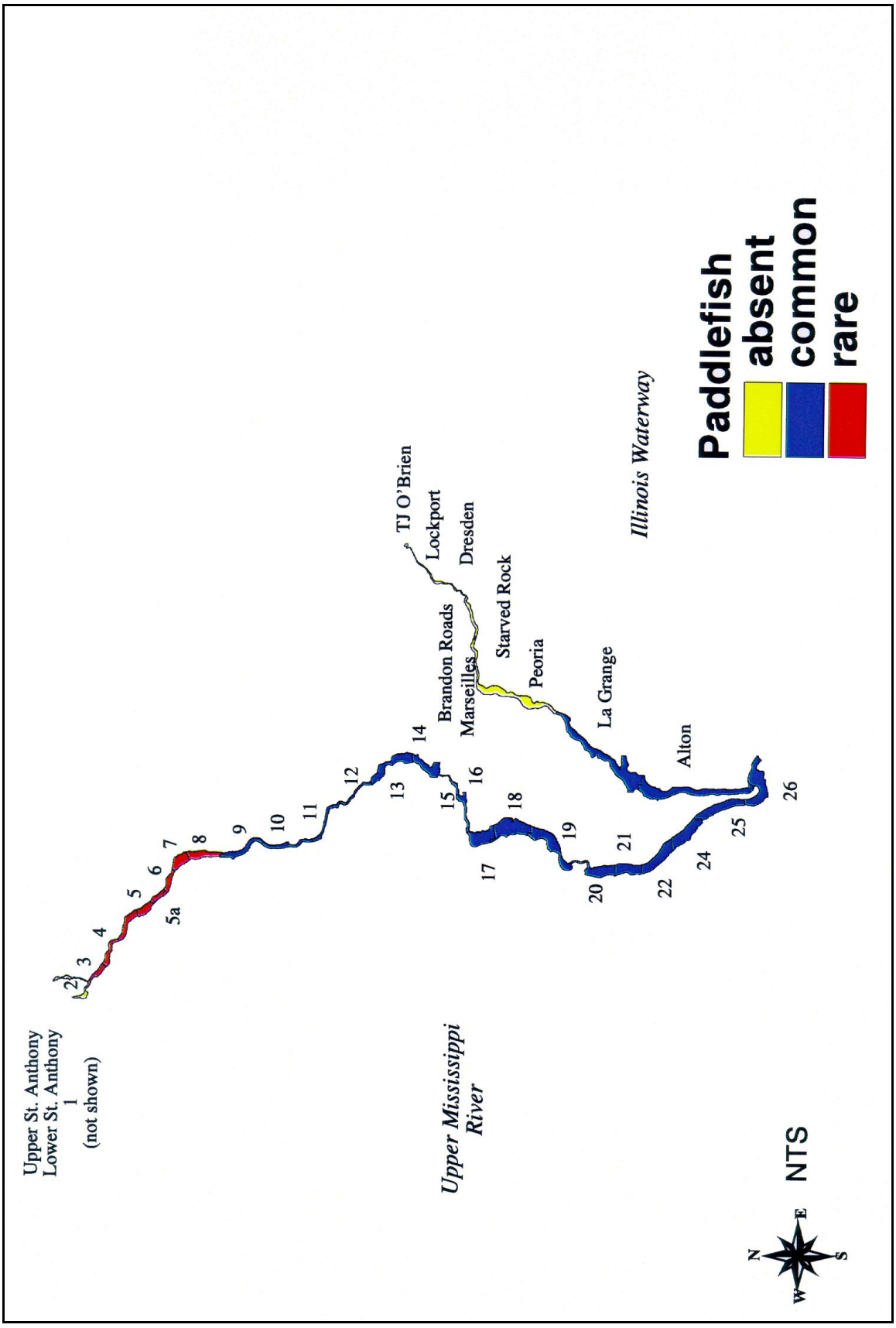

Figure 8. Distribution and abundance of paddlefish in the Upper Mississippi River and the Illinois Waterway

(1), 13 (1), and 26 (3); the open Mississippi River (33); and the IWW La Grange Pool (3) (Burkhardt et al. 1997, 1998; Gutreuter et al. 1997a, 1997b, 1997c, 1997d, 1998). They are listed as threatened by Wisconsin and Minnesota and are on the watch list in Missouri (Table 2). A distinctive feature of the sharklike paddlefish is the long, paddle-shaped snout, whose function is still a matter of debate (Pflieger 1997). While the meat of paddlefish continues to have a ready market, the recent heavy utilization of paddlefish eggs for caviar has dramatically increased the commercial demand (Etnier and Starnes 1993). Paddlefish are apparently more adaptable to impoundments and increased silt deposition than are the sturgeons (Etnier and Starnes 1993).

The paddlefish inhabits quiet, slow-flowing, open waters (Pflieger 1997), most often in main channel border and tailwater habitats (Scott and Crossman 1973; Moen et al. 1992) (Figures 2, 3, and 4). The paddlefish is a continuously swimming, filter-feeding planktivore. It has long, closely spaced gill rakers (Eddy and Underhill 1974). Paddlefish make upstream spawning runs and spawn in large, free-flowing rivers over sand and pebbles near gravel bars that are subject to sustained inundation during spring floods (Holland-Bartels et al. 1990b; Etnier and Starnes 1993). They also successfully use tailwater areas below dams with seasonal success dependent directly on spring water flow levels (Etnier and Starnes 1993). Spawning occurs from March to June, but not all adults spawn every year (Carlander 1969; Holland-Bartels et al. 1990b). Paddlefish larvae have been rarely collected, and little is known of their early life history requirements. However, because of their reproductive strategy, paddlefish larvae are suspected to occur in the main channel drift (Holland et al. 1984; Holland-Bartels et al. 1990b). Paddlefish are long-lived; individuals 20 years old are common, and some live 30 years or more (Pflieger 1997).

Gars

Gars represent the only living family of Lepisosteiformes, an ancient order of bony fishes. This family (Lepisosteidae) has only one existing genus, *Lepisosteus*, for which seven species have been described (Scott and Crossman 1973). Four species occur in the UMR-IWW System, and the shortnose gar is common in most of the system (Van Vooren 1983) (Figure 9).

The shortnose gar, which is a piscivore, inhabits open turbid rivers, quiet pools, backwaters, and oxbows (Holland-Bartels et al. 1990b). It is one of the smaller gars and is somewhat more generalized in its food habits (Pflieger 1997). The shortnose gar is apparently better adapted to murky environments than other species of gar (Pflieger 1997). They spawn in backwaters or grassy, shallow sloughs from May to July (Becker 1983; Holland-Bartels et al. 1990b; Pflieger 1997). Larvae are closely associated with vegetation and are rarely collected in drift studies (Holland-Bartels et al. 1990b) (Figure 2). Little information is available on the ecology of the early life history stages in the UMR.

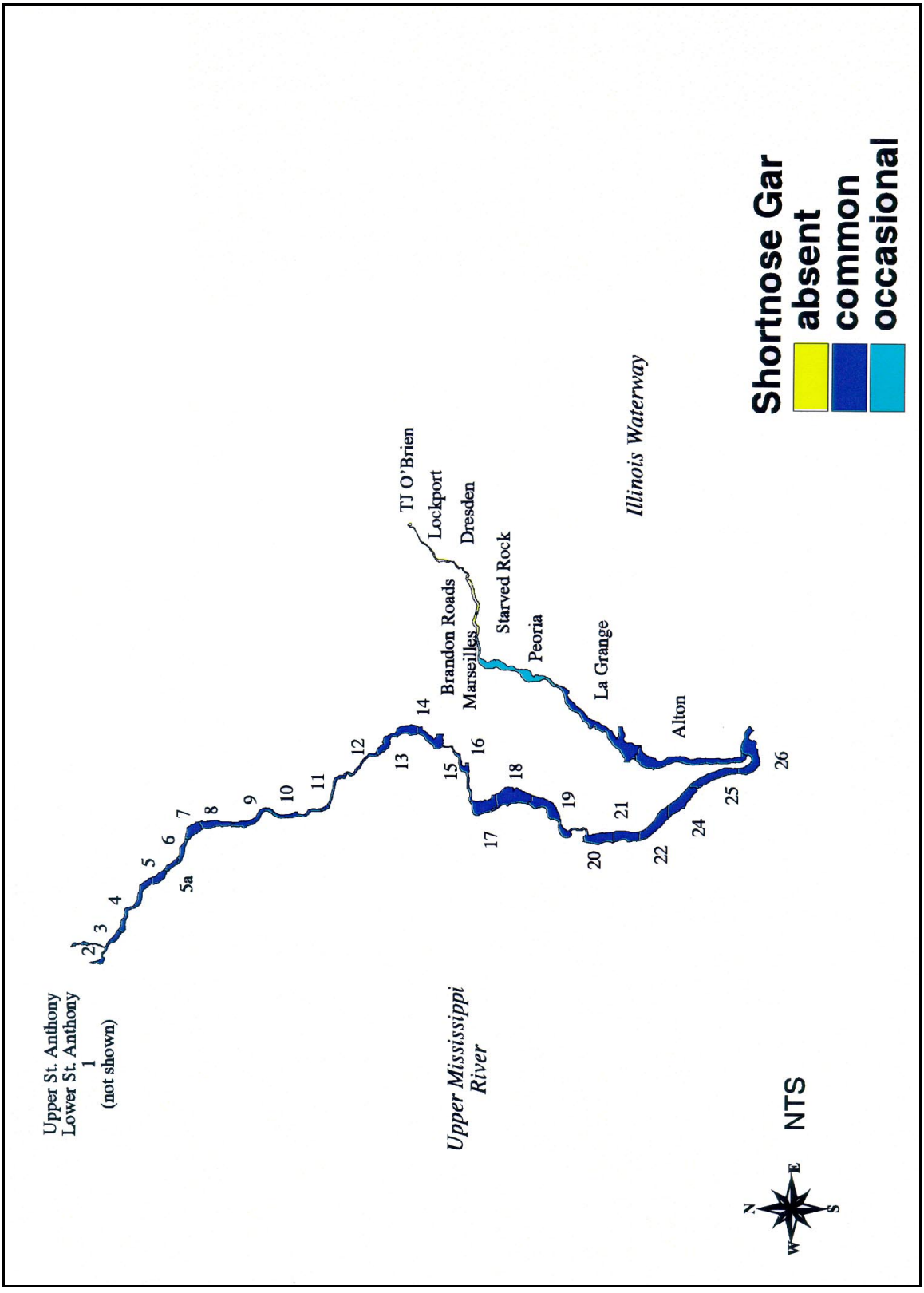

Figure 9. Distribution and abundance of shortnose gar in the Upper Mississippi River and the Illinois Waterway

Bowfins

The bowfin (Family Amiidae) are the only living representatives of the order Amiiformes and only one species, *Amia calva*, exists (Holland-Bartels et al. 1990b). Bowfin are piscivorous and live in sluggish rivers and lakes where the water is clear and the vegetation is abundant (Carlander 1969); their habitat also includes oxbows, marshes, and harbors (Figure 4). They are commonly found in the UMR and occasionally occur in the IWW (Figure 10). Little information is available on the requirements and ecology of the early life stages in the UMR (Holland-Bartels et al. 1990b).

Bowfin spawn in shallow, sluggish, weedy, or stagnant water; nests are constructed and fanned by a male until a clean bed of roots, sand, or gravel is formed (Holland-Bartels et al. 1990b). The nests and fry are vigorously guarded by the male (Becker 1983; Pflieger 1997). Spawning occurs from April to June (Holland-Bartels et al. 1990b; Pflieger 1997).

Herrings

The Clupeidae or herring family is primarily marine and contains only a few freshwater species. Many species are anadromous, spending most of their adult life in salt water but ascending freshwater streams to spawn (Pflieger 1997). Herrings are certainly among the most valuable commercial fishes in the world, being important food fishes in many countries and serving as a chief source of fishmeal for animal feeds; in addition, some species provide an extremely important forage base for game fishes (Etnier and Starnes 1993). Four species (Alabama shad (*Alosa alabamae*), skipjack herring (*Alosa chrysochloris*), gizzard shad, and threadfin shad (*Dorosoma petenense*)) are found in the UMR, but only gizzard shad are common (Van Vooren 1983).

Gizzard shad, which are planktivores, inhabit quiet waters that may range from clear to extremely turbid; they avoid high-gradient streams and prefer waters of high productivity, such as the large, permanent pools in the UMR-IWW System (Pflieger 1997). Gizzard shad travel in large schools near the surface and are considered an important forage species (Scott and Crossman 1973).

Gizzard shad are abundant in all pools of the UMR-IWW System (Figure 11) and are found in virtually all habitats of the river system (Figures 2, 3, and 4). Gizzard shad spawn from April through August in the UMR-IWW System, and spawning occurs in sloughs, ponds, lakes, large rivers, and protected bays over sand, gravel, and boulders (Holland-Bartels et al. 1990b; Etnier and Starnes 1993). Larvae are present in the ichthyoplankton drift in June and July and are much more numerous in backwaters than in main channel areas (Holland-Bartels et al. 1990b; Gutreuter, Dettmers, and Wahl 1998). Larval gizzard shad are twice as abundant at dusk than at any other time (Holland and Sylvester 1983).

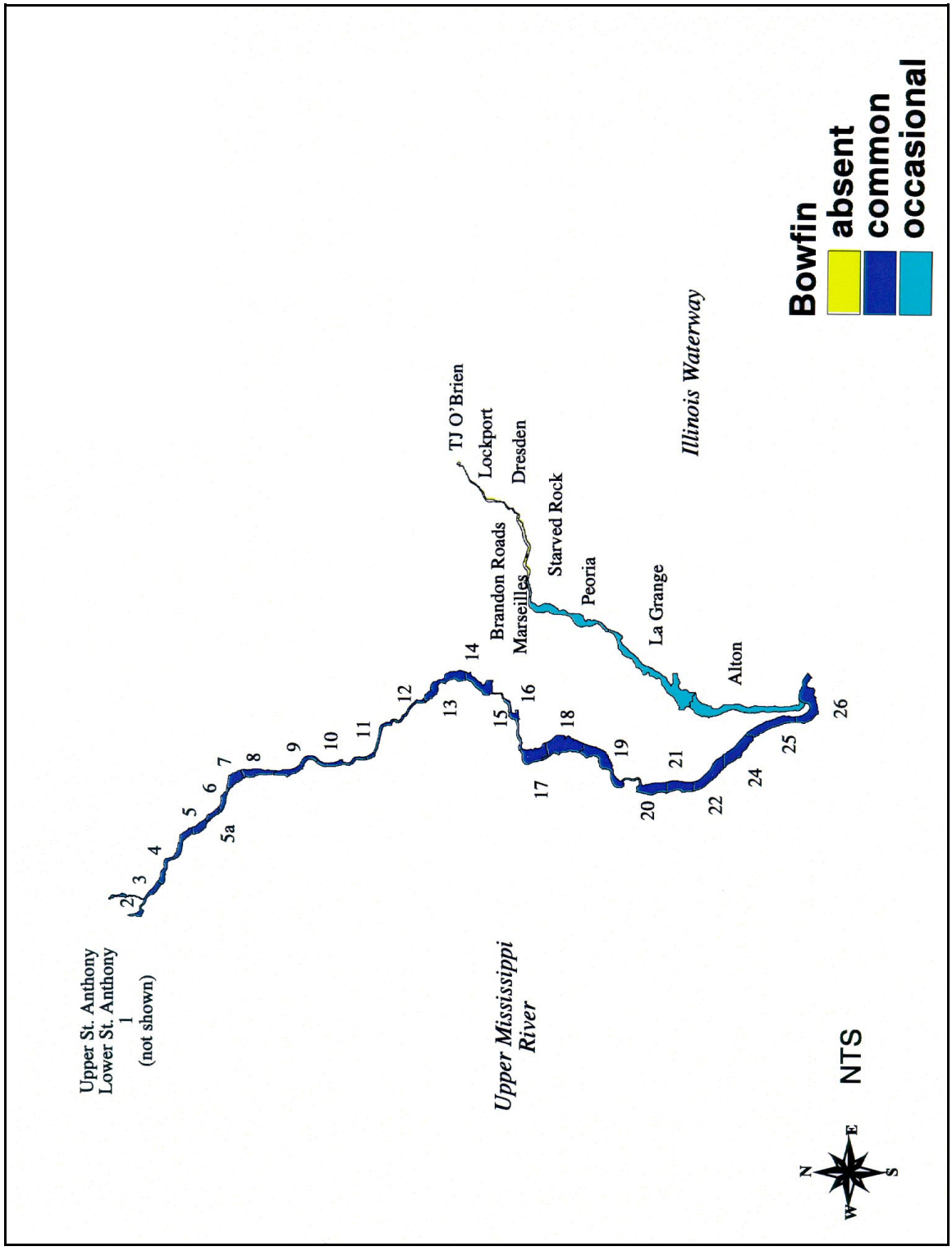

Figure 10. Distribution and abundance of bowfin in the Upper Mississippi River and the Illinois Waterway

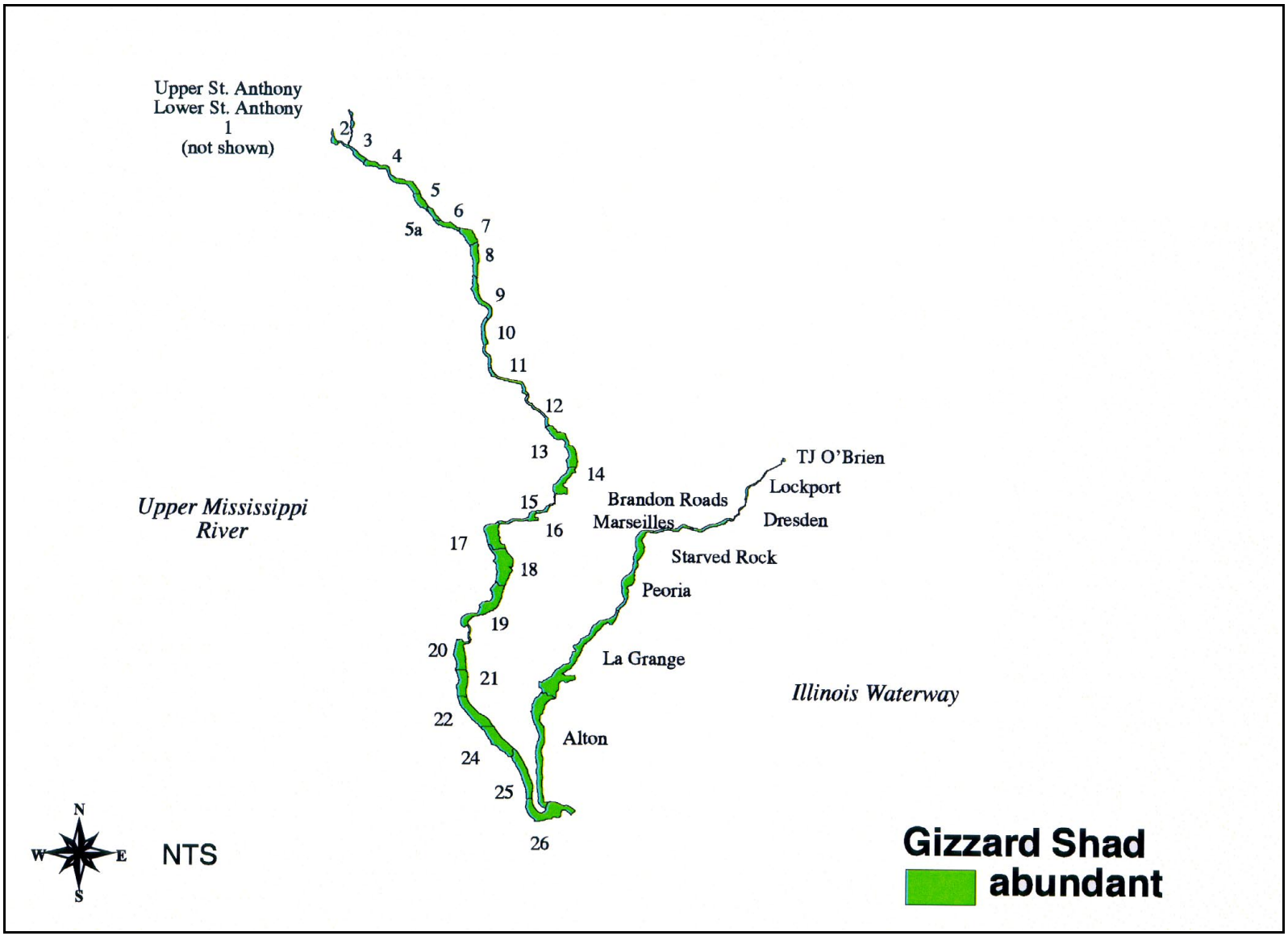

Figure 11. Distribution and abundance of gizzard shad in the Upper Mississippi River and the Illinois Waterway

Mooneyes

The primitive, strictly North American family, Hiodontidae, consists of a single genus containing two omnivorous species: the goldeye and the mooneye (Holland-Bartels et al. 1990b). Adult goldeye inhabit quiet, turbid waters of major rivers; their large eyes are adapted to dim light (Carlander 1969; Becker 1983). The species is rarely to occasionally found in the UMR and common in much of the IWW (Figure 12). Goldeye are listed as endangered by the state of Wisconsin (Table 2). Little information is available on the early life history of the goldeye in the UMR (Holland-Bartels et al. 1990b). Goldeye spawn in April and May in pools or backwater areas of turbid rivers (Scott and Crossman 1973; Holland-Bartels et al. 1990b); only half of females spawn in any given year (Grosslein and Smith 1959).

Mooneye are commonly to occasionally found in the UMR-IWW System (Figure 13); they are listed as rare by the state of Missouri (Table 2). This species inhabits large, quiet pools of streams and lakes and has a lower tolerance for silt than the goldeye (Carlander 1969). Larvae are only rarely collected in the main channel drift and occur in May and June; they are found in vegetation in backwater and main channel border habitats (Holland et al. 1983; Holland-Bartels et al. 1990b). Mooneye migrate up clear streams to spawn in April and May (Becker 1983).

Pikes

Pikes (Family Esocidae) are distributed extensively from the arctic to the subtropical regions of the Northern Hemisphere (Scott and Crossman 1973). Of the five species found in North America, three occur in the UMR-IWW System, but only the northern pike occurs regularly (Holland-Bartels et al. 1990b). Northern pike are commonly found in the upper pools of the UMR, while they occur occasionally in the lower pools of the UMR and the IWW (Figure 14). The northern pike is listed as rare by the state of Missouri (Table 2).

Northern pike inhabit a variety of habitats, including lakes, reservoirs, and large streams (Pflieger 1997). They occur primarily in clear, warm, slow, meandering, heavily vegetated rivers, or in warm, weedy bays of lakes (Holland-Bartels et al. 1990b). Northern pike are piscivorous (Littlejohn et al. 1985), and adults prefer shallow water in the spring and fall and move to deep water during the summer (Scott and Crossman 1973).

Northern pike spawn in heavily vegetated floodplains of rivers, marshes, and bays over plant material (Etnier and Starnes 1993; Pflieger 1997); spawning occurs in March and April (Becker 1983). Newly hatched northern pike attach themselves to flooded emergent vegetation by an adhesive organ on their snout (Holland-Bartels et al. 1990b) (Figure 2). Since they remain in shallow nursery areas, northern pike larvae rarely appear in standard towed or set plankton net collections of ichthyoplankton (Farabee 1979). Juveniles remain in or near submerged vegetation throughout their first summer (Holland and Huston 1984) (Figure 3).

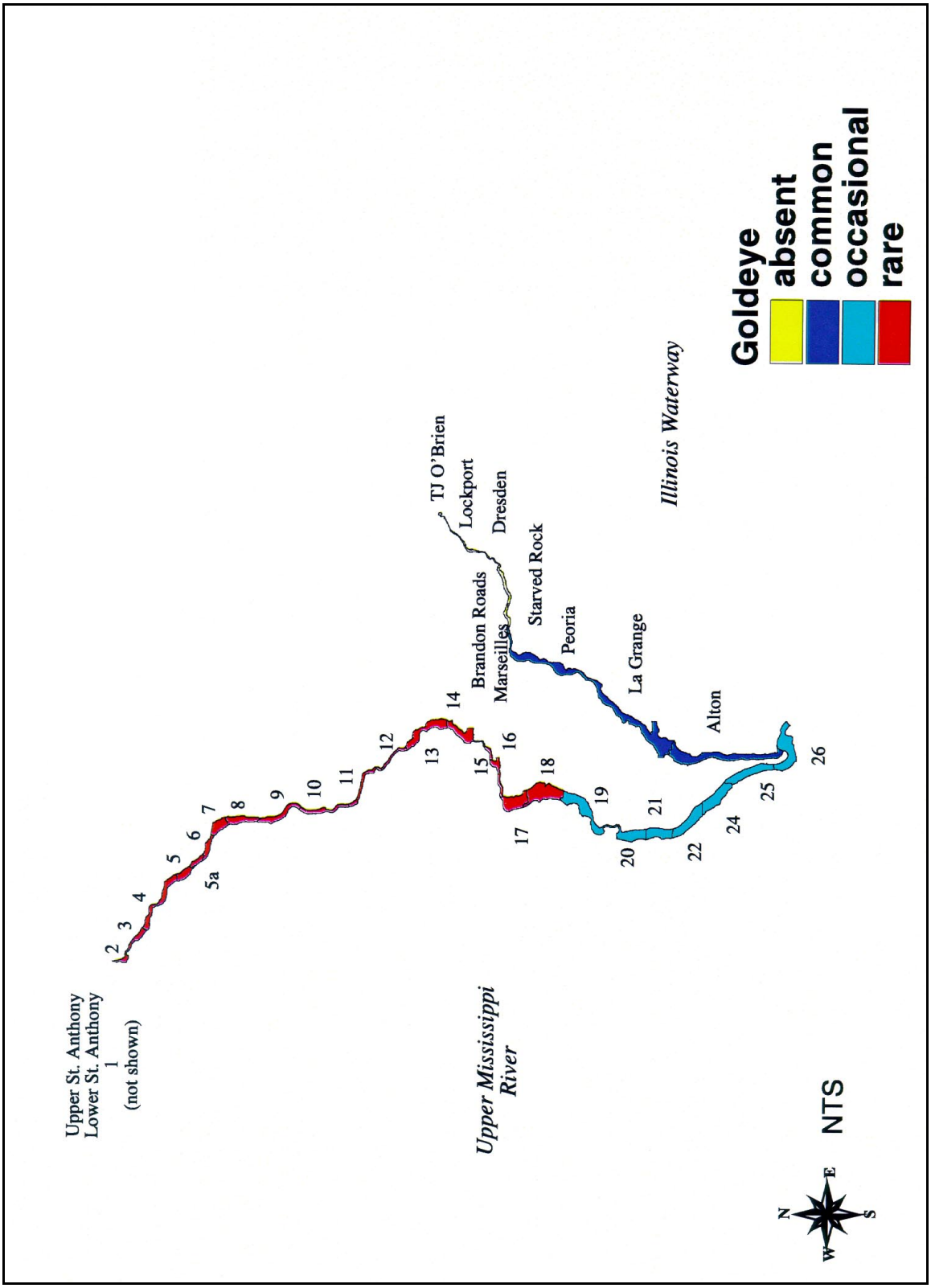

Figure 12. Distribution and abundance of goldeye in the Upper Mississippi River and the Illinois Waterway

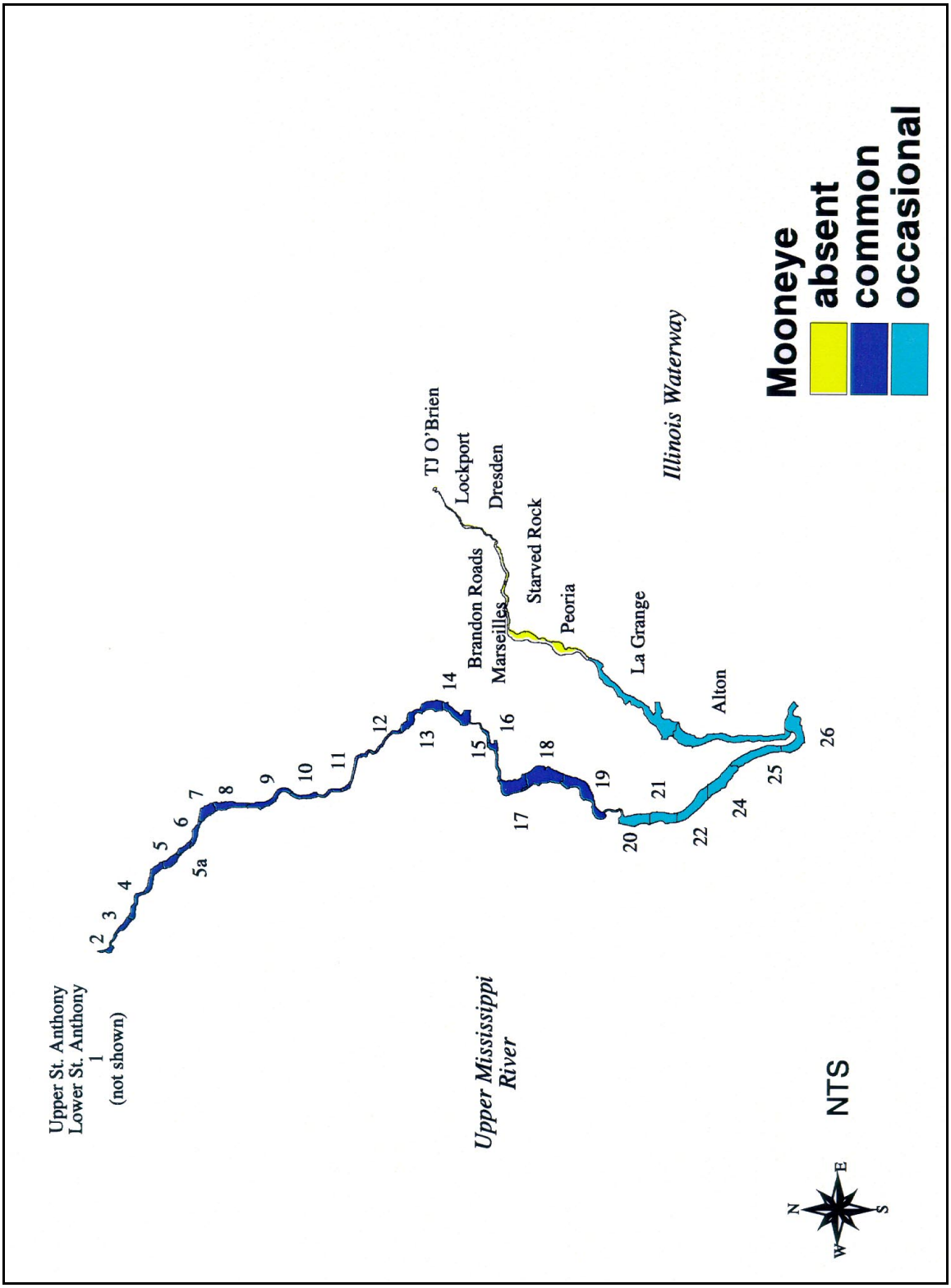

Figure 13. Distribution and abundance of mooneye in the Upper Mississippi River and the Illinois Waterway

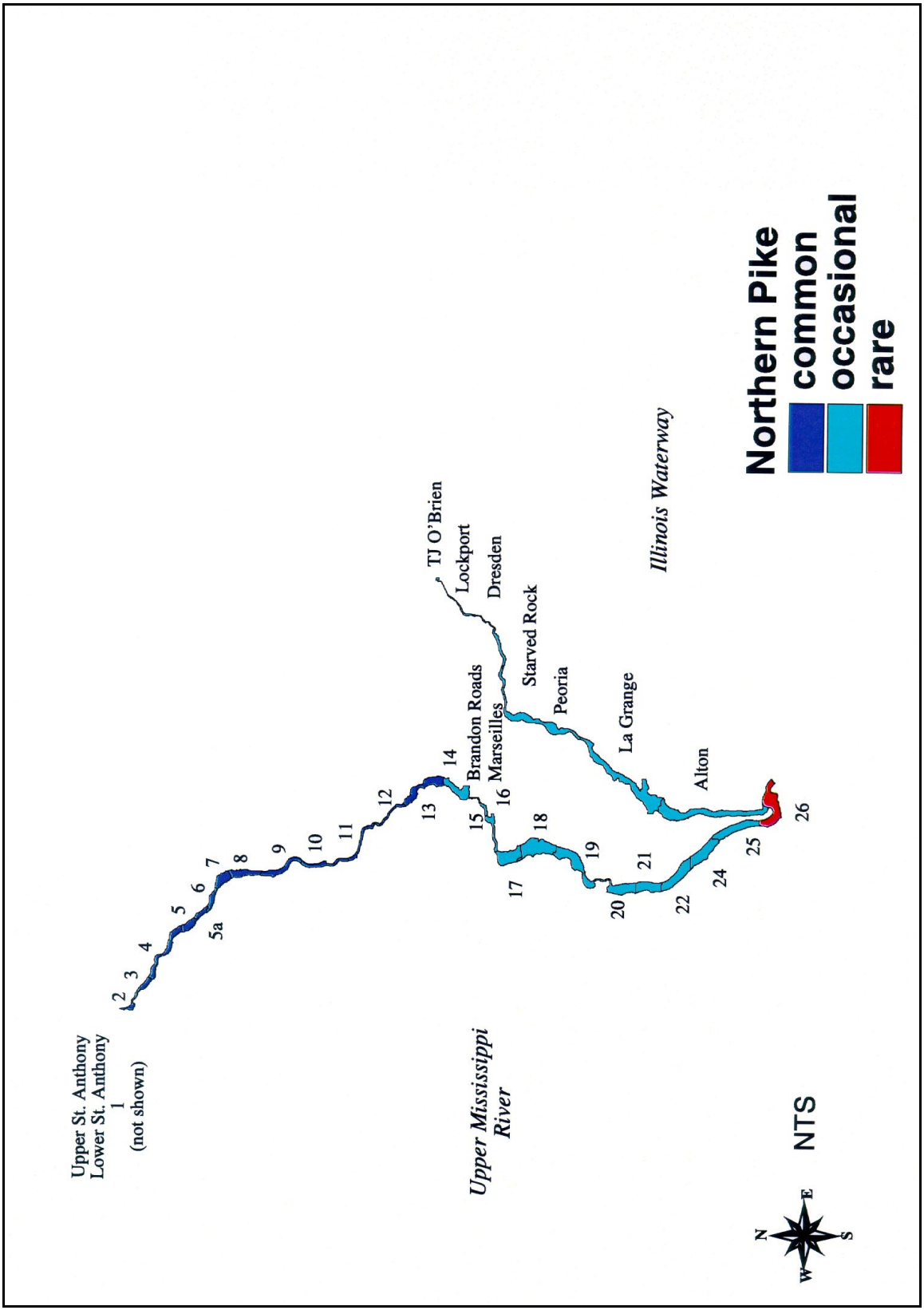

Figure 14. Distribution and abundance of northern pike in the Upper Mississippi River and the Illinois Waterway

Minnows

Minnows (Family Cyprinidae) constitute one of the largest families of fishes in the world; there are more than 1,500 species, and they occur on every continent except South America and Australia (Scott and Crossman 1973; Pflieger 1997). Two minnow species were selected for this ecological risk assessment: the common carp, an important commercial species, and emerald shiner, an important forage species.

Common carp were successfully introduced into North America from Europe in 1877 and have spread throughout many river systems in the United States (Eddy and Underhill 1974). Common carp have become so abundant in suitable habitats that they are often accused of competing for food and space with more desirable fish species; their feeding habits frequently result in a general deterioration of the habitat through increased turbidity and the destruction of aquatic vegetation (Pflieger 1997). The nuisance qualities of common carp may be somewhat exaggerated although a basis exists for being concerned (Pflieger 1997). The common carp is an omnivore found in the main channel, main channel border, and backwater areas (Figure 4); they are abundant in the entire UMR-IWW System (Figure 15). Carp prefer the relatively warm water of shallow, mud-bottomed lakes and large streams (Becker 1983); they are especially prevalent in highly productive lakes, streams, and man-made impoundments (Pflieger 1997). Common carp spawn in shallow, weedy areas of lakes, marshes, and swamps; in ponds and sheltered vegetated areas of streams; or over tree roots, aquatic vegetation, and mud bottoms (Holland-Bartels et al. 1990b). Spawning occurs from May through early August (Swee and McCrimmon 1966; Becker 1983). Larval carp are most abundant in backwaters, but they also occur in the main channel drift; they are present from early May through late August and are at peak densities from mid-June to mid-July (Holland-Bartels et al. 1990b; Gutreuter, Dettmers, and Wahl 1998). Larval carp show a strong diel drift pattern (Holland and Sylvester 1983). Juvenile common carp most often occur in shallow weedy areas but have been collected from a wide variety of habitats (Farabee 1979).

The emerald shiner is the most common minnow in the Mississippi River, and it is abundant throughout the UMR-IWW System (Figure 16). The emerald shiner, which is tolerant of a wide range of turbidity and bottom types, lives in the main, open channels of large, low-gradient streams where there is noticeable current (Etnier and Starnes 1993; Pflieger 1997) (Figures 2, 3, and 4). This species is omnivorous (Littlejohn et al. 1985), and schools of emerald shiner stay close to the surface or at middepths (Trautman 1957). Emerald shiners spawn just beneath the surface in shallow water over sand or firm mud from late May to mid-August (Holland-Bartels et al. 1990b; Pflieger 1997). Larval emerald shiners are particularly common in the main channel drift with peak abundance near mid-June (Holland et al. 1984; Holland-Bartels et al. 1990b).

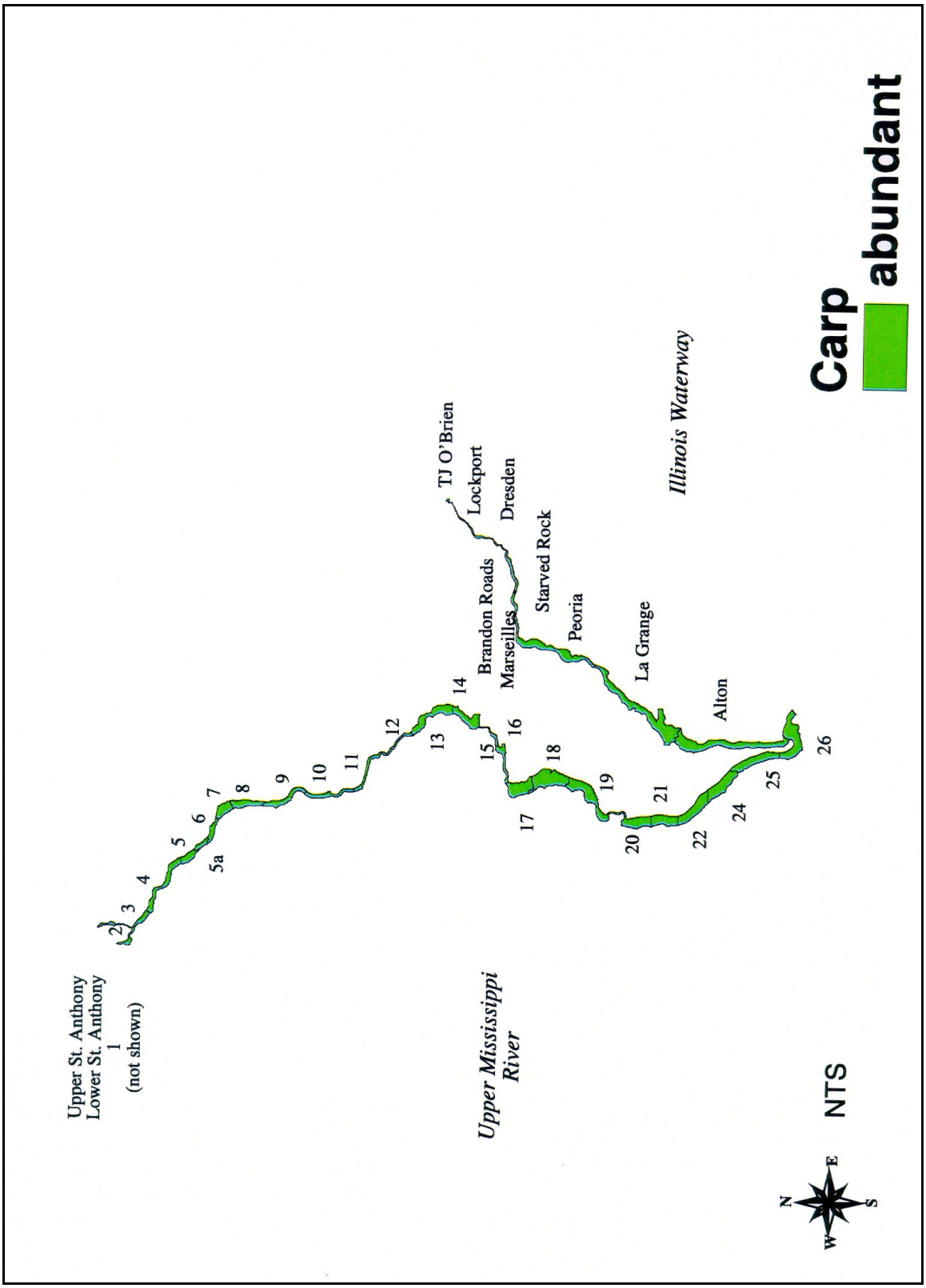

Figure 15. Distribution and abundance of carp in the Upper Mississippi River and the Illinois Waterway

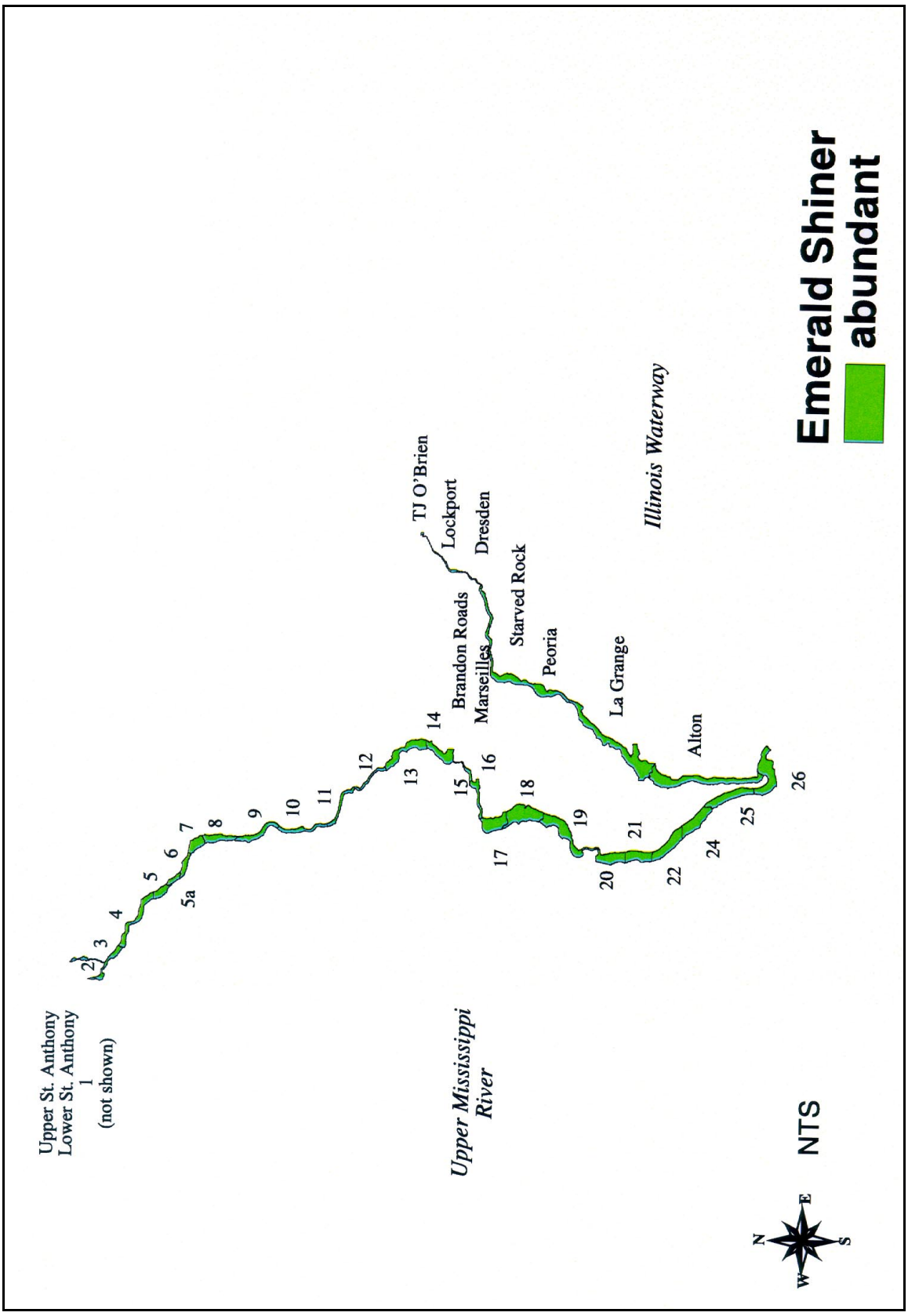

Figure 16. Distribution and abundance of emerald shiner in the Upper Mississippi River and the Illinois Waterway

Suckers

The sucker family (Catostomidae) is a large family of mainly freshwater North American fishes consisting of about 60 species (Becker 1983); eleven species are common in the UMR-IWW System (Van Vooren 1983). Suckers are generally bottom-dwellers and omnivorous (Littlejohn et al. 1985; Holland-Bartels et al. 1990b). Sucker species selected for this ecological risk assessment include the river carpsucker, blue sucker, smallmouth buffalo, bigmouth buffalo, spotted sucker, and shorthead redhorse.

The river carpsucker prefers quiet, still pools, backwaters, and oxbows of large streams with low gradients (Holland-Bartels et al. 1990b) (Figure 4). It occurs in large schools, feeds at the bottom, and seems to prefer turbid water (Pflieger 1997). Adult river carpsuckers have been commonly collected in most of the UMR-IWW System (Figure 17). River carpsuckers spawn from May through July over silt or sand bottoms of rivers or tributaries but not in lakes or reservoirs (Jester 1972; Smith 1979; Holland-Bartels et al. 1990b); they are most successful in years of high water levels when meadows or marshes flood (Walburg 1976). River carpsucker larvae are common in backwater habitats of the UMR and are consistently collected in the main channel drift; peak densities occur in late May (Holland 1985; Holland-Bartels et al. 1990b) (Figure 2).

The blue sucker is listed as threatened in Wisconsin, is a species of special concern in Minnesota, and is on the watch list in Missouri (Table 2). The blue sucker is rare in the UMR and absent from the IWW (Figure 18). Small numbers of blue sucker have consistently been collected in the LTRMP fish surveys in UMR Pools 4, 8, 13, 26 and in the open Mississippi River from 1991 through 1997 (Burkhardt et al. 1997, 1998; Gutreuter et al. 1997a, 1997b, 1997c, 1997d, 1998). This highly mobile fish may be more abundant and widespread than available records suggest because it is not readily captured by the sampling gear and techniques ordinarily used in fish surveys (Pflieger 1997). Dams have likely been detrimental to this migratory species (Pflieger 1997). Blue suckers, which are bottom feeders, inhabit the main river channel in areas that are deep with swift currents over a bottom of sand, gravel, or rock (Etnier and Starnes 1993; Pflieger 1997). Most of these habitats occur where the channel is constricted by natural or artificial obstructions, including bedrock or boulder riffles and the tailwaters of dams, wing dikes, and bridge abutments (Pflieger 1997). The blue sucker is tolerant of high turbidity if there is sufficient current to prevent the deposition of silt (Pflieger 1997). Spawning occurs from late April through June (Rupprecht and Jahn 1980; Pflieger 1997).

Smallmouth buffalo prefer clean, clear, deep waters with a moderate current; they live in pools, oxbows, and the deeper water of large rivers (Becker 1983). Smallmouth buffalo are the most abundant species of *Ictiobus* in the UMR (Holland-Bartels et al. 1990b); the general habitat of this fish is the main channel (Littlejohn et al. 1985) (Figure 4). Smallmouth buffalo are commonly to occasionally found in the UMR-IWW System (Figure 19). They spawn from April through June in shallow areas, randomly over the bottom, and often in vegetation that may be submerged or floating; they prefer to spawn in marshes or